transported through the channel into a collection reservoir, so that the molecule of interest was purified away from the mixture.

[0011] Another motor protein device is shown in Japanese patent 5-44298 (JP 5-44298), which describes a pump for moving liquid. Actin is mounted onto a surface of a container in the direction of the desired flow, and meromyosin and ATP are supplied in the liquid. The interaction of the meromyosin and actin "push" the liquid in the direction of flow.

[0012] Nicolau et al., *SPIE* 3241:36-46, 1997 discusses constructing a molecular motor or engine using actin and myosin. A rotatable gear is mounted on a stationary base, and the gear has teeth to which arms of actin are attached. Using lithographic techniques of the type used in semiconductor fabrication, a track of myosin is laid down along the peripheral edge of the stationary base so that the arms of actin on the rotatable gear can adhere to the track, and pull the teeth of the gear along the myosin track when ATP is supplied to the system. This arrangement is apparently designed to rotate the gear, and impart rotation to a driven gear that engages the driving gear. However, the myosin track in such a device would be crushed by the teeth of the gear as the gear rotates, or would jam.

[0013] Moreover, precise microlithographic positioning of the actin and myosin molecules would be difficult, and perhaps unfeasible, and alignment of the actin arms along the myosin track could not be maintained. It also does not appear that the molecular motor could be scaled up to macroscopic proportions, nor is it clear how the power or speed of the device could be controlled.

[0014] It is a goal of certain embodiments of the present disclosure to solve some of the problems of prior approaches by devising a molecular motor that is more easily fabricated, and may if desired be scaled up to macroscopic proportions.

[0015] It is also a goal of some embodiments to devise such a molecular motor in which power and speed of the motor can be more conveniently controlled.

SUMMARY OF THE DISCLOSURE

[0016] The molecular motor of the present disclosure includes first and second complementary two dimensional arrays of a motor protein, for example adhered to a substrate surface. The first and second arrays of motor proteins are in sufficiently close contact to interact and directionally move one array (and its attached substrate) relative to the other. This action in turn moves a driven member, such as a shaft or gear, to convert the movement into useful power that can produce work.

[0017] In some embodiments, there are multiple layers of nested (for example concentric) complementary first and second arrays that interact with one another to directionally move the first and second arrays relative to one another. The arrays may be adhered to a curved surface, such as, for example, a continuous curved surface of rotation having a longitudinal axis and an internal radius (for example a cylinder or cone). Alternatively, the arrays may be adhered to a planar surface of an annular substrate, such as, for example, a disc or a ring. According to a further variation, the arrays may be adhered to a flexible continuous loop surface that can transform between a curved surface and a planar surface as the loop rotates around internal radii. Multiple concentric cylinders, nested cones, concentric rings, or nested loops (which rotate around a common central longitudinal axis) can form a series of complementary surfaces to which the arrays are adhered.

[0018] In particular embodiments, the motor proteins are actin and myosin, and the motor includes a source of ATP for activating the myosin to operate the motor. The ATP can be supplied in a liquid that flows longitudinally through the rotatable surfaces on which the arrays are adhered, or the ATP containing liquid may be infused through perforations in surfaces on which the arrays are disposed, to allow permeation of an ATP containing liquid through the surfaces to the motor proteins.

[0019] When actin/myosin are the motor proteins, the actin may be applied directionally to a substrate surface and the myosin is applied to a complementary or opposing substrate surface. The actin-coated surface and the myosin-coated surface are in sufficiently close contact that the motor proteins interact to move the surfaces relative to one another, in a direction determined by the directional application of the actin to its surface.

[0020] An array of the first motor protein may be coated on a first curved or planar surface, and an array of the second motor protein may be coated on a second complementary curved or planar surface, such that the first and second motor proteins interact to move the second surface in a predetermined direction relative to the first surface. In an illustrative example, one of the arrays is coated on an outer surface of a cylinder, shaft or cone, and another of the arrays is coated on an inner surface of a surrounding structure having a complementary shape that substantially conforms to a shape of the outer surface of the cylinder, shaft or cone. The directional movement of the second surface moves a driver, such as an internal shaft or cylinder in the motor. Alternatively, the driver may be an outer curved surface of the motor (such as an outer surface of an outermost cylinder of the motor). The driven member can take a variety of forms, such as a rotating shaft, a propeller, a wheel, a lever-arm, a gear system, or a pulley system.

[0021] An advantage of the disclosed motor is that the arrays can be of a preselected dimension that provides a preselected power output of the motor. For example, the length of a cylinder on which the complementary arrays are coated can be selected to vary the power output. Alternatively, a speed of rotation of the motor can be varied by preselecting the number of multiple nested complementary arrays or the number of stacked, array-coated annular substrates. Alternatively, the speed of rotation can be controlled by altering the concentration of ATP to which the motor proteins are exposed. As the concentration of ATP increases, the speed of the motor will increase up to a maximum speed, at which all the motor proteins are maximally functioning.

[0022] In a more specific embodiment, the molecular motor includes a series of concentric tubes or hollow cones, wherein each of the tubes or hollow cones has an outer surface and an inner surface. A first motor protein array (such as an actin array) is attached in a continuous ring of a selected width around the outer surface of each of the tubes or cones, and a second motor protein (such as myosin) is attached in a continuous complementary array of a corresponding width around the inner surface of each of the tubes or cones.